USGS
science for a changing world

A guidance manual to support the assessment of contaminated sediments in freshwater ecosystems

Chris Ingersoll
U.S. Geological Survey, Columbia, MO

Don MacDonald
MacDonald Environmental Sciences Ltd., Nanaimo, BC

USEPA meeting on Issues in Assessing and Managing Ecological Risks at Contaminated Sediment Sites; June 4, 2002 in Chicago, IL

U.S. Department of the Interior
U.S. Geological Survey

Topics

- Overview of the USEPA GLNPO guidance manual for assessing contaminated sediments
- Development of consensus-based Probable Effect Concentrations (PECs)
- Evaluation of the predictive ability of mean PEC quotients (PEC-Qs) on a local, regional, and national basis

USGS

USEPA (2002) sediment manual

- Three volume set:
  1. An Ecosystem-based Framework for Assessing and Managing Contaminated Sediments
  2. Design and Implementation of Sediment Quality Investigations
  3. Interpretation of Results of Sediment Quality Investigations
- Take home message: **Integration of multiple lines of evidence in an assessment of sediment quality**
- Separate publications by USEPA GLNPO, British Columbia, and the state of Florida

USGS

USEPA (2002): Volume 1

- Ecosystem-based sediment quality assessment:
  - Sediment-dwelling organisms
  - Aquatic-dependent wildlife
  - Human health
- Identification of issues and concerns
- Establishing goals and objectives
- Selection of indicators, metrics, and targets
- Designated water uses
- Bibliography of relevant publications

USGS

USEPA (2002): Volume 2

- Design and implementation of sediment quality investigations:
  - Framework for assessing and managing sediment quality
  - Types and objectives of sediment quality assessments
  - Sampling and analysis plan
  - Preliminary site investigation
  - Detailed site investigation
  - Remedial action planning

USGS

USEPA (2002): Volume 3
Indicators of sediment quality (5 lines)

1. Effects-based sediment quality guidelines (SQGs) for whole sediment or toxicity thresholds for pore water
2. Whole-sediment and pore-water toxicity tests
3. Benthic invertebrate community assessment
4. Bioaccumulation assessment
5. Fish health and fish community surveys
6. Integration of information from multiple lines of evidence

USGS

Overview of each indicator (e.g., Sediment toxicity testing)

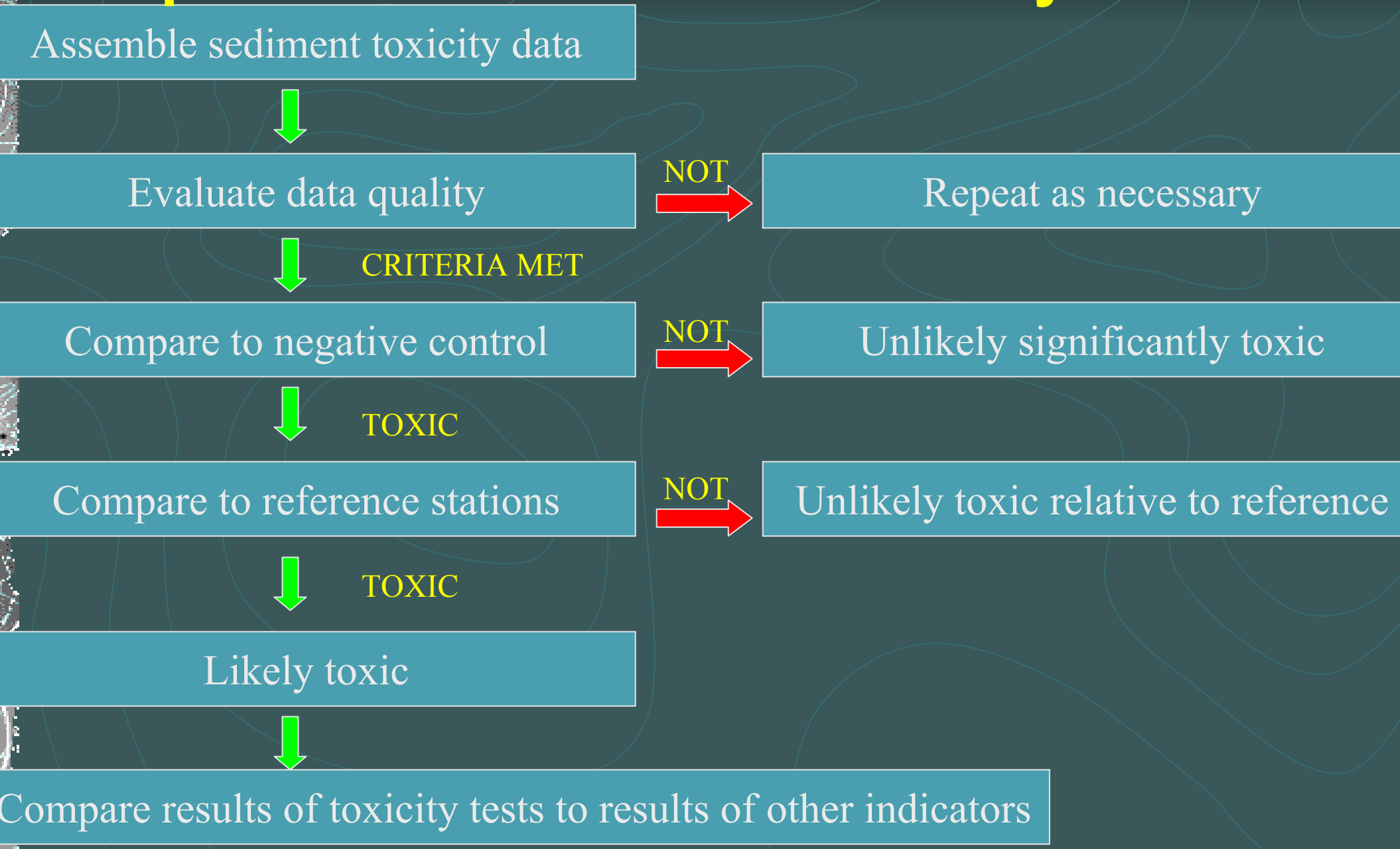
- Introduction
- Selection of metrics and targets
- Availability of standard methods
- Advantages and disadvantages
- Evaluation of data quality
- Methodological uncertainty (i.e., SETAC 1997)
- Interpretation of data
- Recommendations

USGS

Sediment quality indicators, metrics, and targets

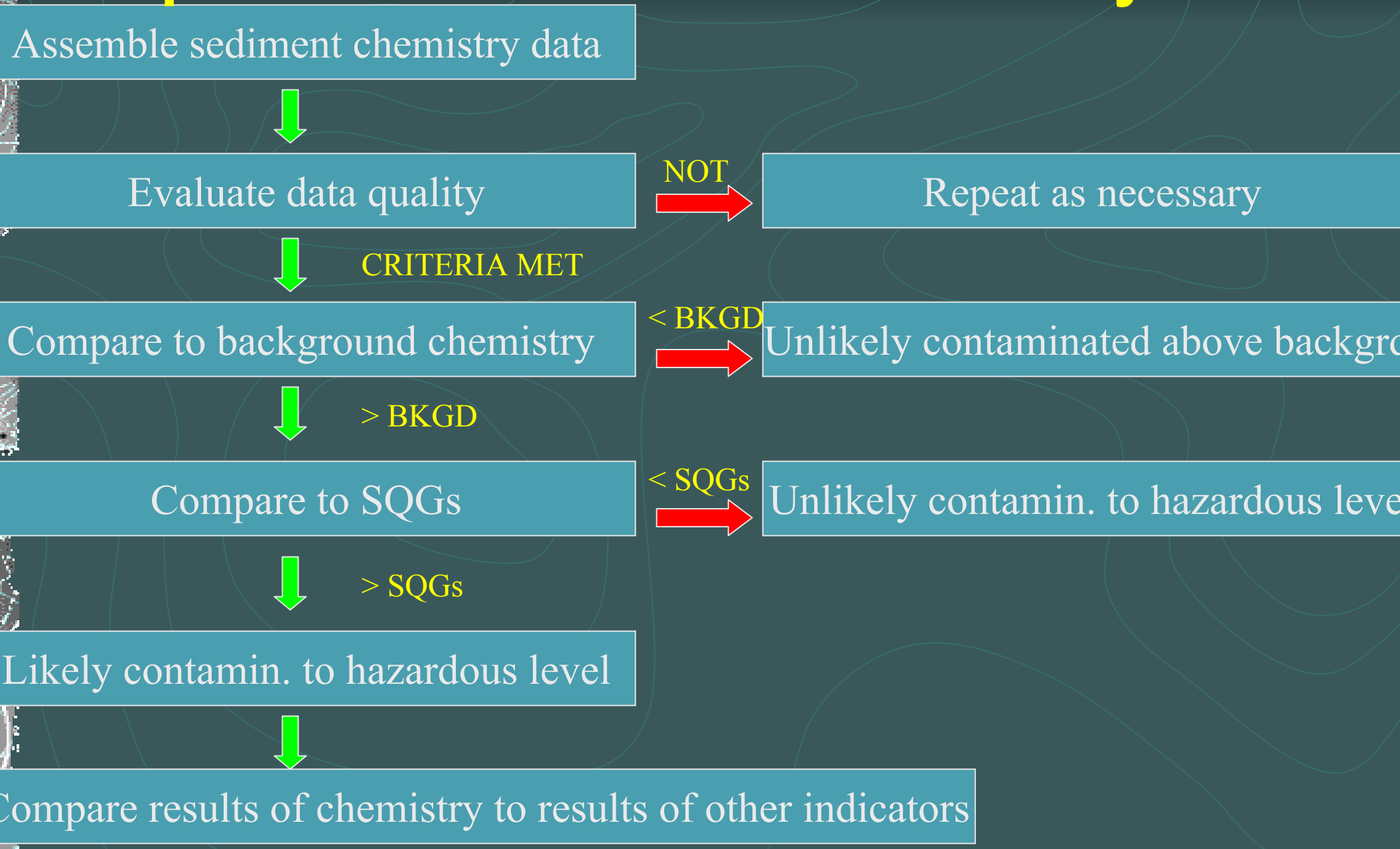
USGS

Interpretation of sediment toxicity data



USGS

Interpretation of sediment chemistry data



USGS

Contingency table for 4 lines of evidence

Possible outcome	Chem.	Toxicity	Benthos	Tissue	Possible conclusions
1	+	+	+	+	Impact highly likely: Contaminant-induced degradation in field and bioaccumulation evident.
2	-	-	-	+	Impact unlikely: Exposure due to water, diet, or from other site.
3	+	-	-	+	Impact likely: Contaminants not toxic in sediment, but higher trophic levels likely impacted.
4	-	+	-	+	Impact likely: Unmeasured factors contributing to toxicity and bioaccumulation evident.
5	-	-	+	+	Impact likely: Effects organisms due to contamination and bioaccumulation evident.
6	+	+	-	+	Impact likely: Contaminants stressing organisms and bioaccumulation evident.
7	-	+	+	+	Impact likely: Unmeasured chemicals contributing to toxicity and bioaccumulation evident.
8	+	-	+	+	Impact likely: Toxicity tests not sensitive enough and bioaccumulation evident.

Potential uses of chemically-based sediment quality guidelines (SQGs)

- Interpret historical data
- Identify problem chemicals and areas at site
- Decision tool for detailed study
- Identify problem chemicals before discharge
- Link contaminant source and sediment
- Trigger regulatory action
- Establish target remediation objectives

USGS

Use of SQGs by states or provinces

- States or provinces that have formally (legally) adopted use of SQGs
  - Washington (1995)
- States or provinces that are considering adopting formal use of SQGs in the next several years
  - British Columbia, California, Florida
- States or provinces that informally use SQGs
  - Florida, California, Hawaii, Oregon, South Carolina, New Jersey, Alaska, Texas, Maine, Michigan, Wisconsin, Indiana, Ohio, New York, Montana, Minnesota, Massachusetts, Ontario, Quebec

USGS

Establishing PECs for freshwater sediments

- Development of consensus-based Probable Effect Concentrations (PECs; MacDonald et al. 2000)
- Evaluate predictive ability of PEC-Quotients on national, regional, and local basis (USEPA 2000, Ingersoll et al. 2001, Crane et al. 2002)

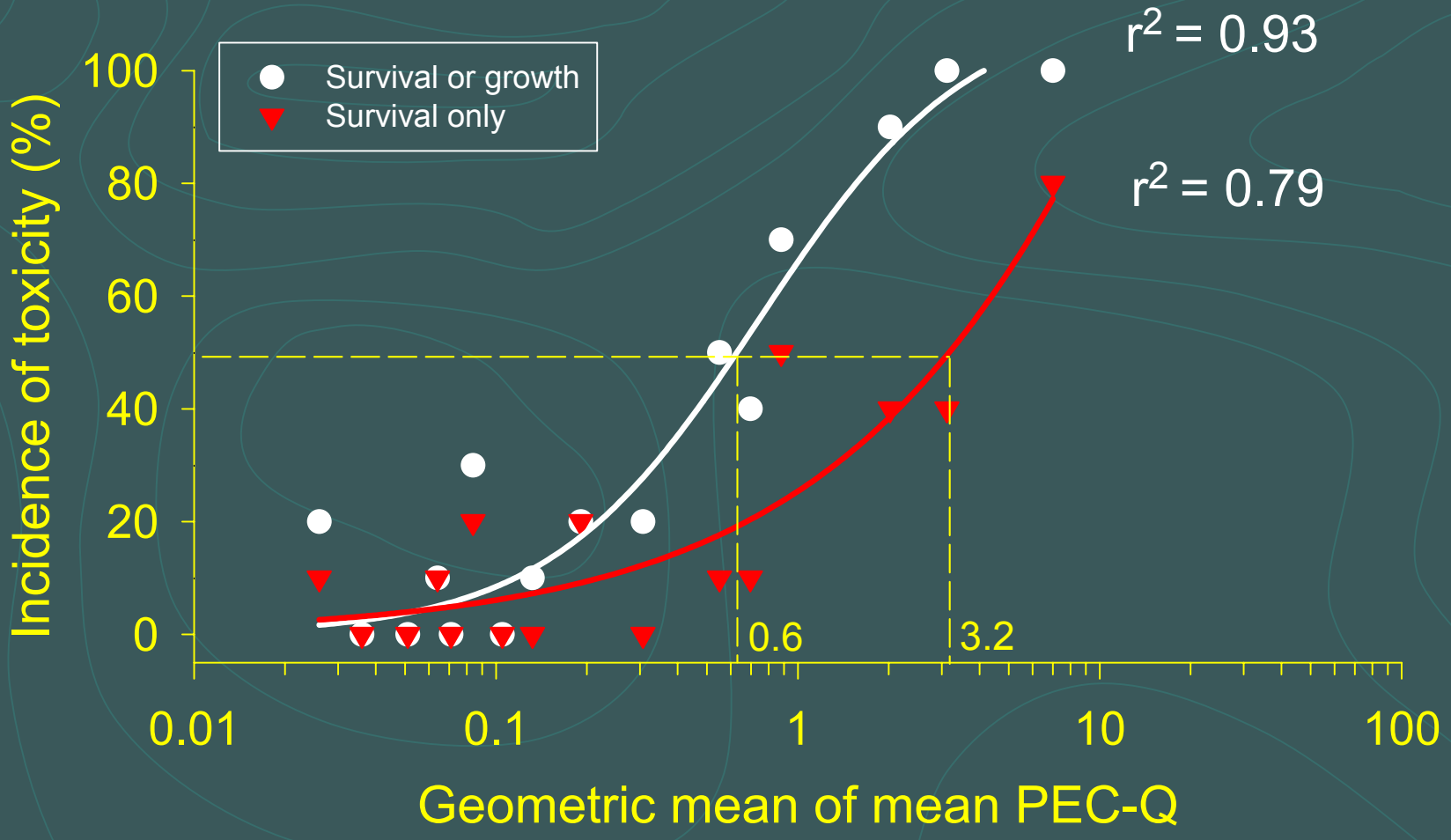
USGS

Development of PECs

- PEC: concentration of an individual contaminant in sediment above which toxicity frequently observed
- Geometric mean of published SQGs = PEC
- Reliability (347 toxicity samples)
  - >75% correct prediction of toxic or not toxic
  - >20 samples predicted to be toxic or not toxic
- Reliable PECs
  - Metals: As, Cd, Cr, Cu, Pb, Ni, Zn
  - PAHs: 7 including total PAHs
  - OCs: total PCBs, sum DDE
- Predictive ability of SQGs (1657 toxicity samples)

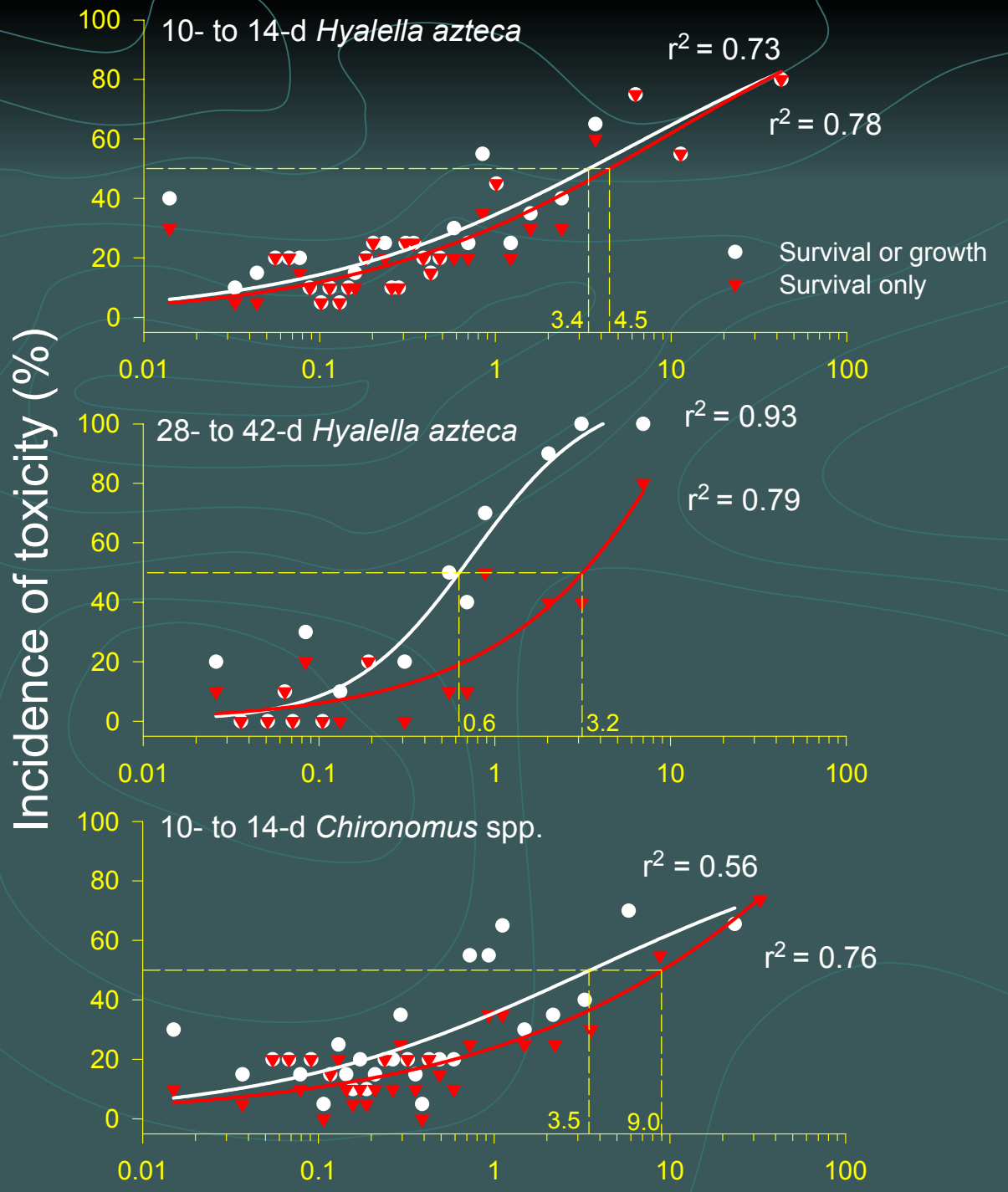
USGS

28- to 42-d *Hyalella azteca*



USGS

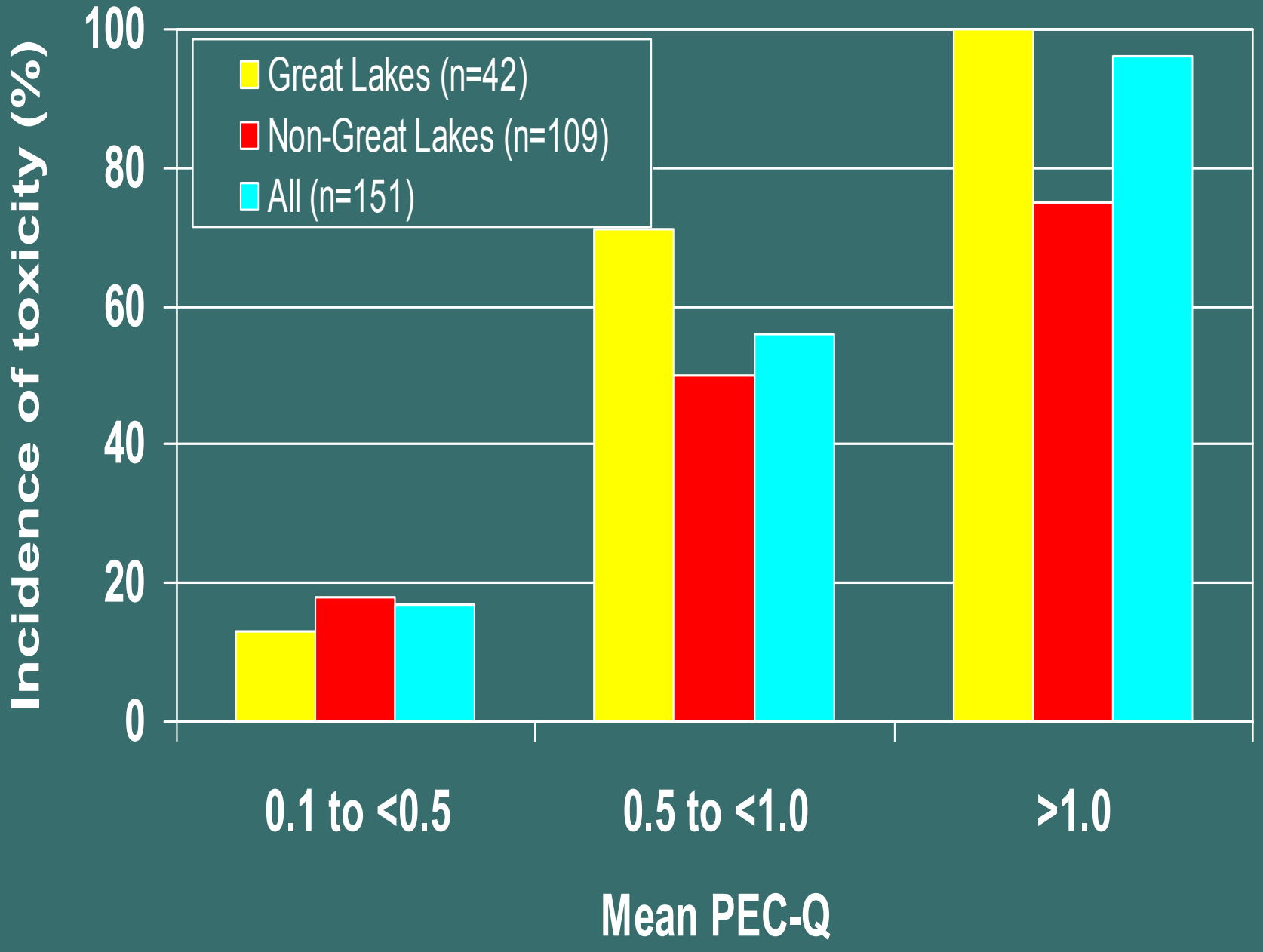
USEPA (200



USGS

USEPA (2000)

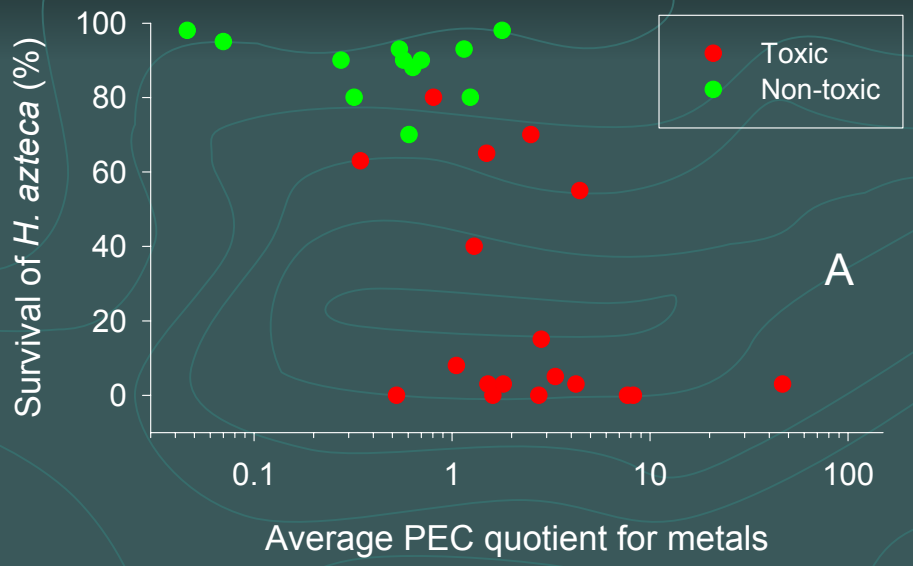
Geographic incidence of sediment toxicity: HA28 test

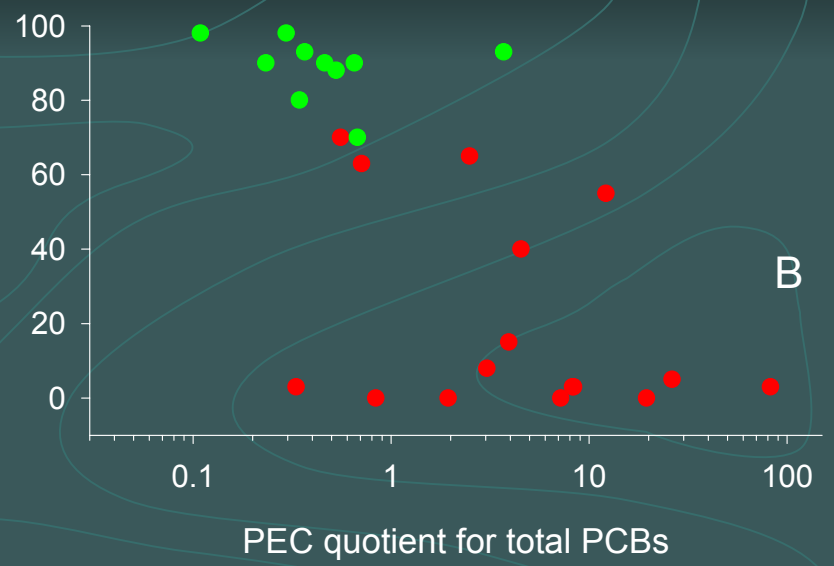


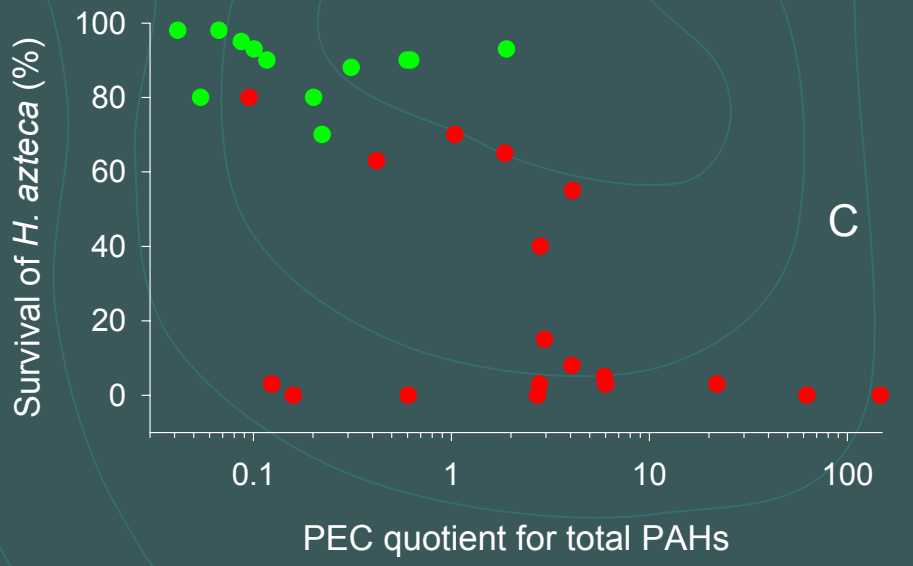
USGS

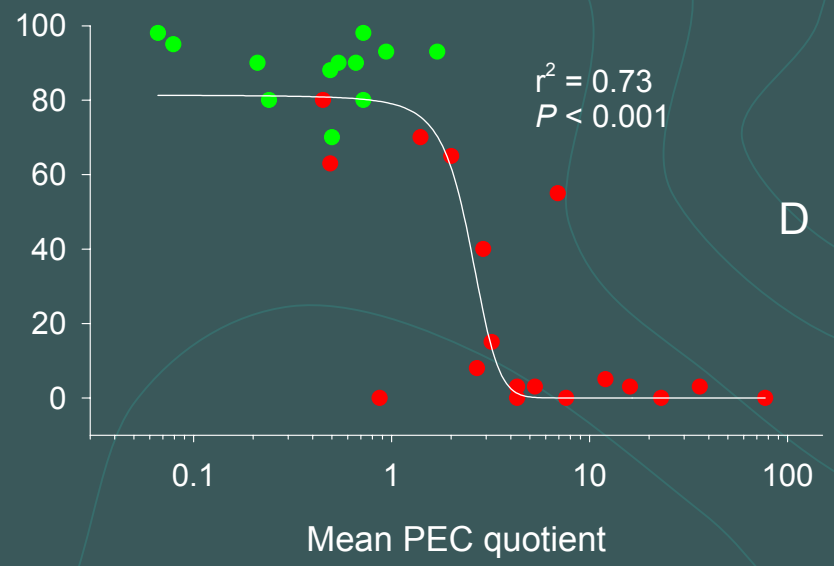
USEPA (2000)

10-d survival of *H. azteca* vs PECs in Indiana Harbor, IN





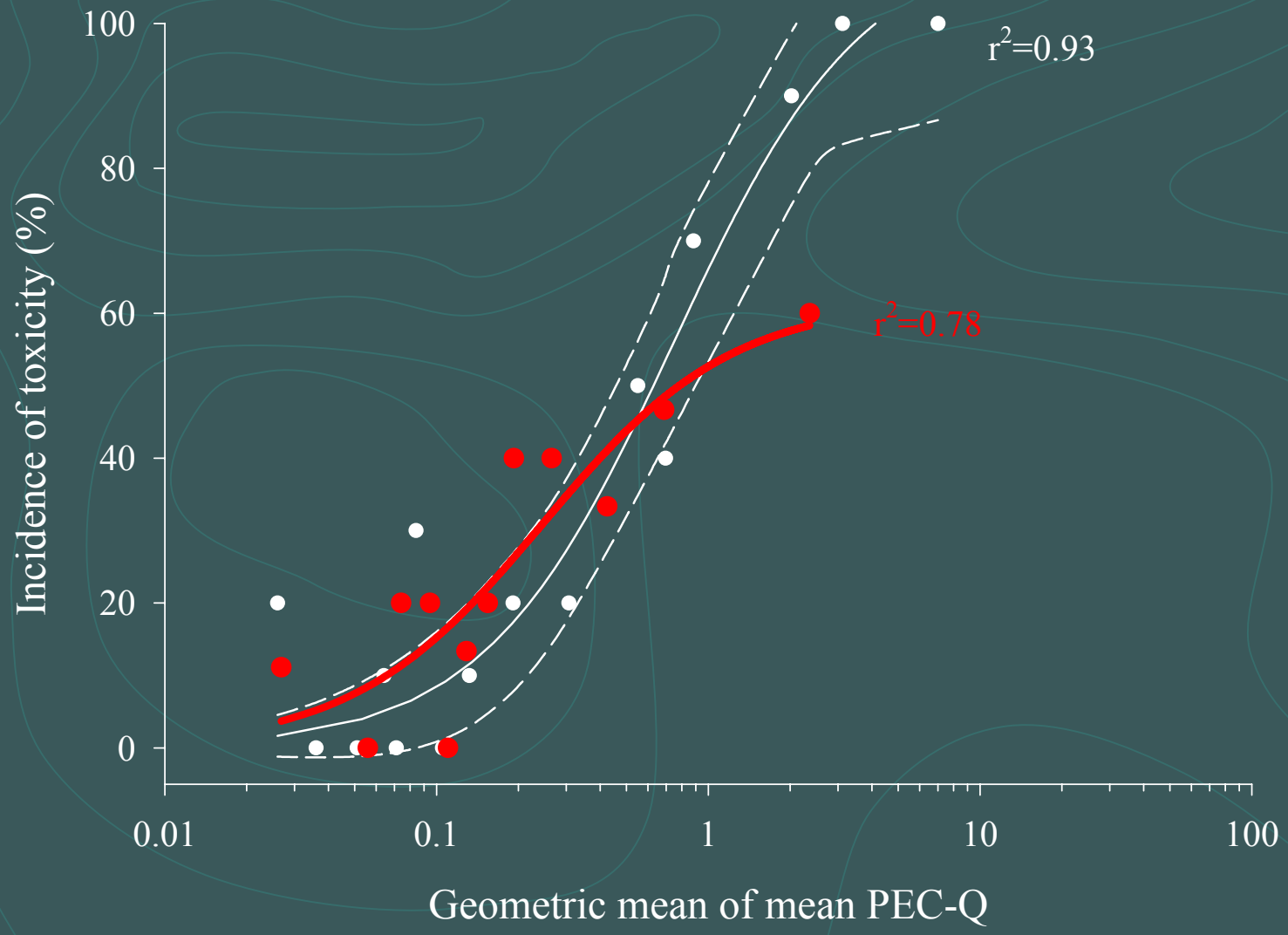




USGS

Ingersoll et al. (2002)

Prediction of toxicity in 28- to 42-d *H. azteca* tests:
National database vs. SE United States

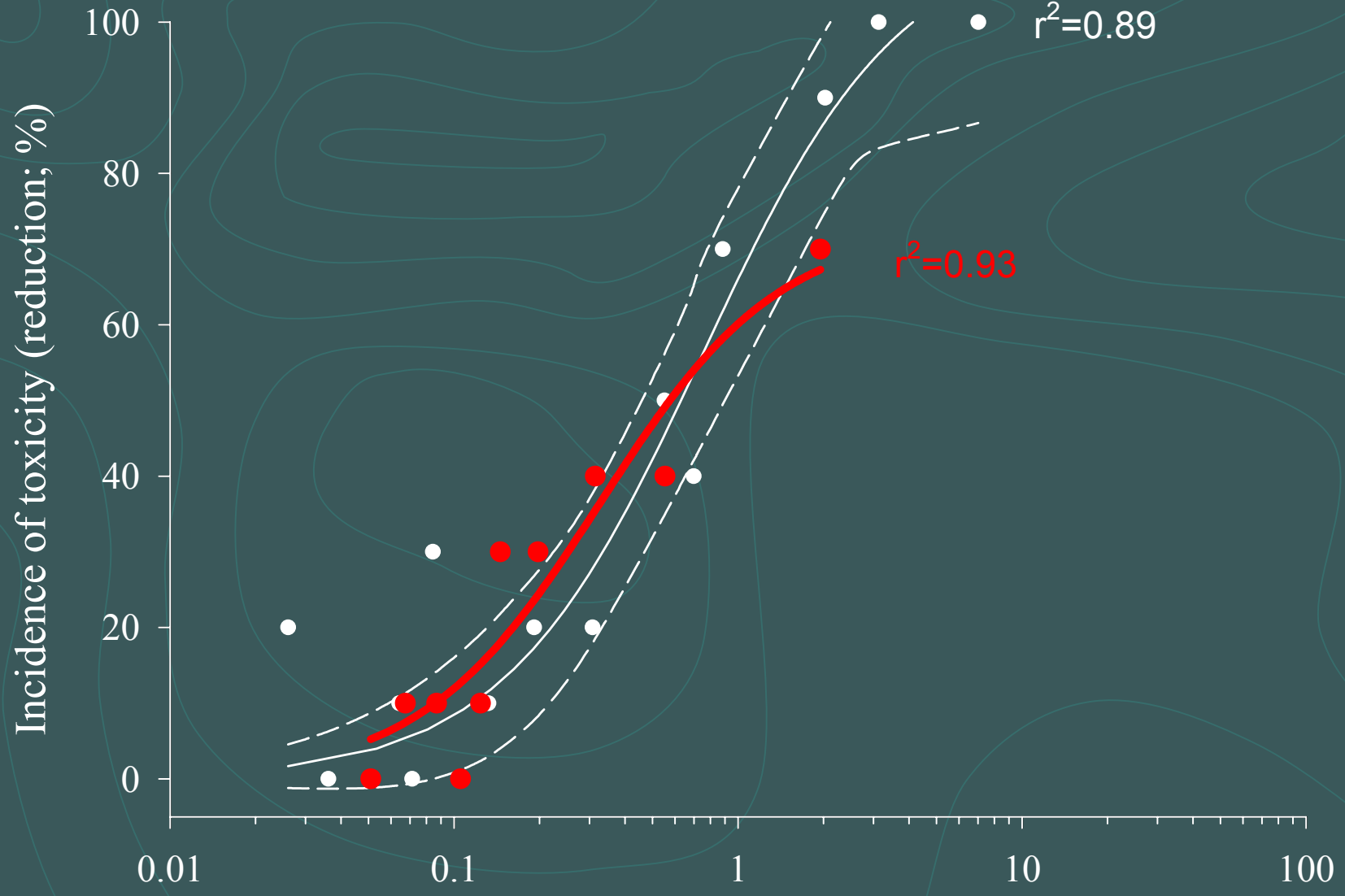


USGS

MacDonald et al. (2002a)

Prediction of toxicity in 28- to 42-d *H. azteca* tests:

National database vs. Calcasieu estuary, LA

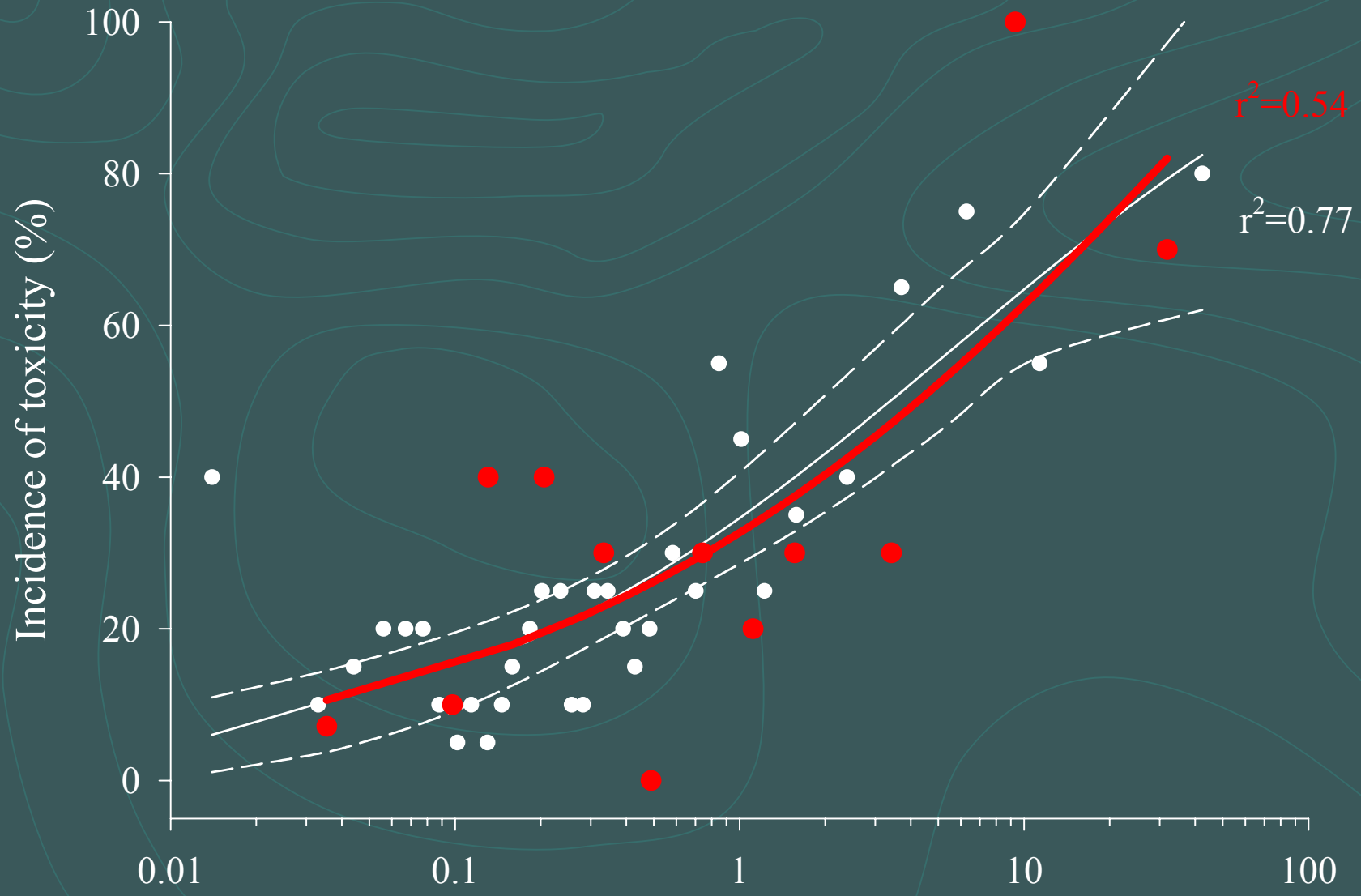


USGS

MacDonald et al. (2002b

Prediction of toxicity in 10- to 14-d *H. azteca* tests

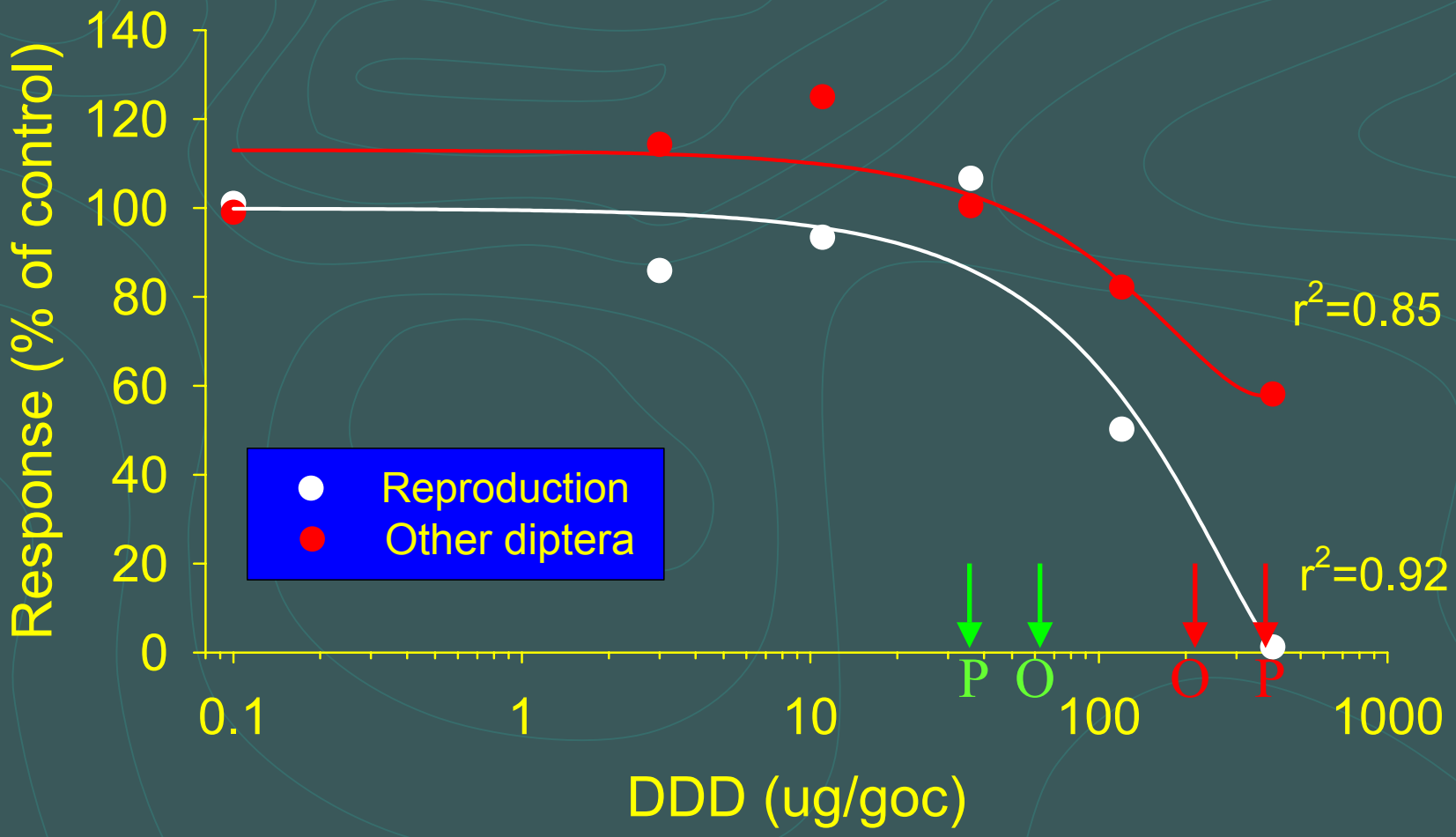
National database vs. Colville Indian Reservation



USGS

MacDonald et al. (2002c)

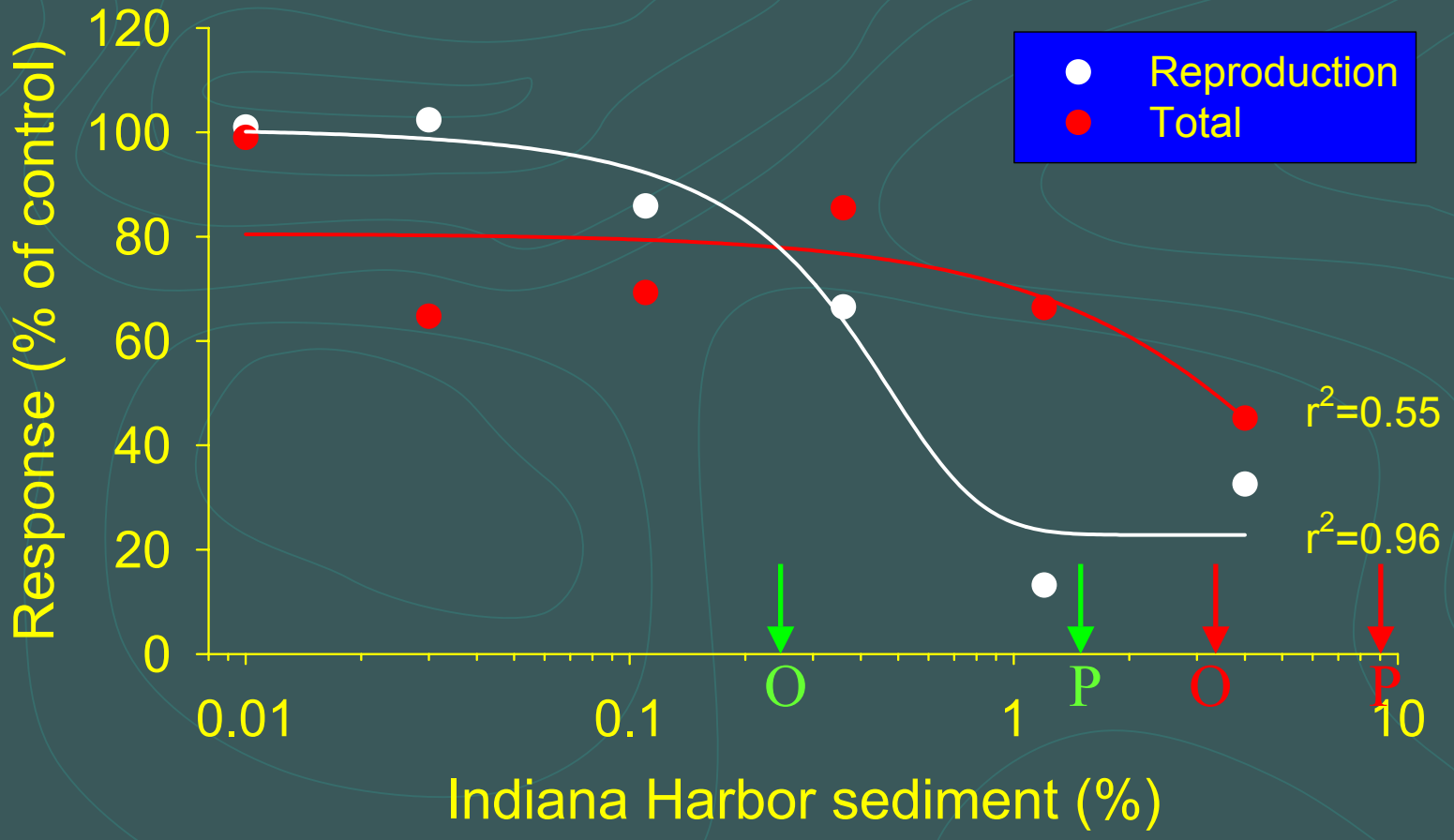
Comparison of Sensitive Endpoints from the Lab and Field Studies with the DDD Sediments



Hayward et al. (2002)

USGS

Comparison of Sensitive Endpoints from the Lab and Field Studies with the Indiana Harbor Sediment Dilutions



Hayward et al. (2002)

USGS

Conclusions

- Consensus-based PECs are reliable and predictive of sediment toxicity in samples on a national and regional basis
- Frequency of toxicity increased at mean PEC-Quotients >0.5
- *H. azteca* 28-d test about 6x sensitive than in 10-d tests
- SETAC Workshop planned for August 2002

USGS

“The weight of evidence required should depend on the weight of the decision”

Dave Mount
USEPA, Duluth, MN
SETAC short course
November 1997

USGS